Scheduling Improvements Following the Phase 1 Field Evaluation of the ATD-2 Integrated Arrival, Departure, and Surface Concept

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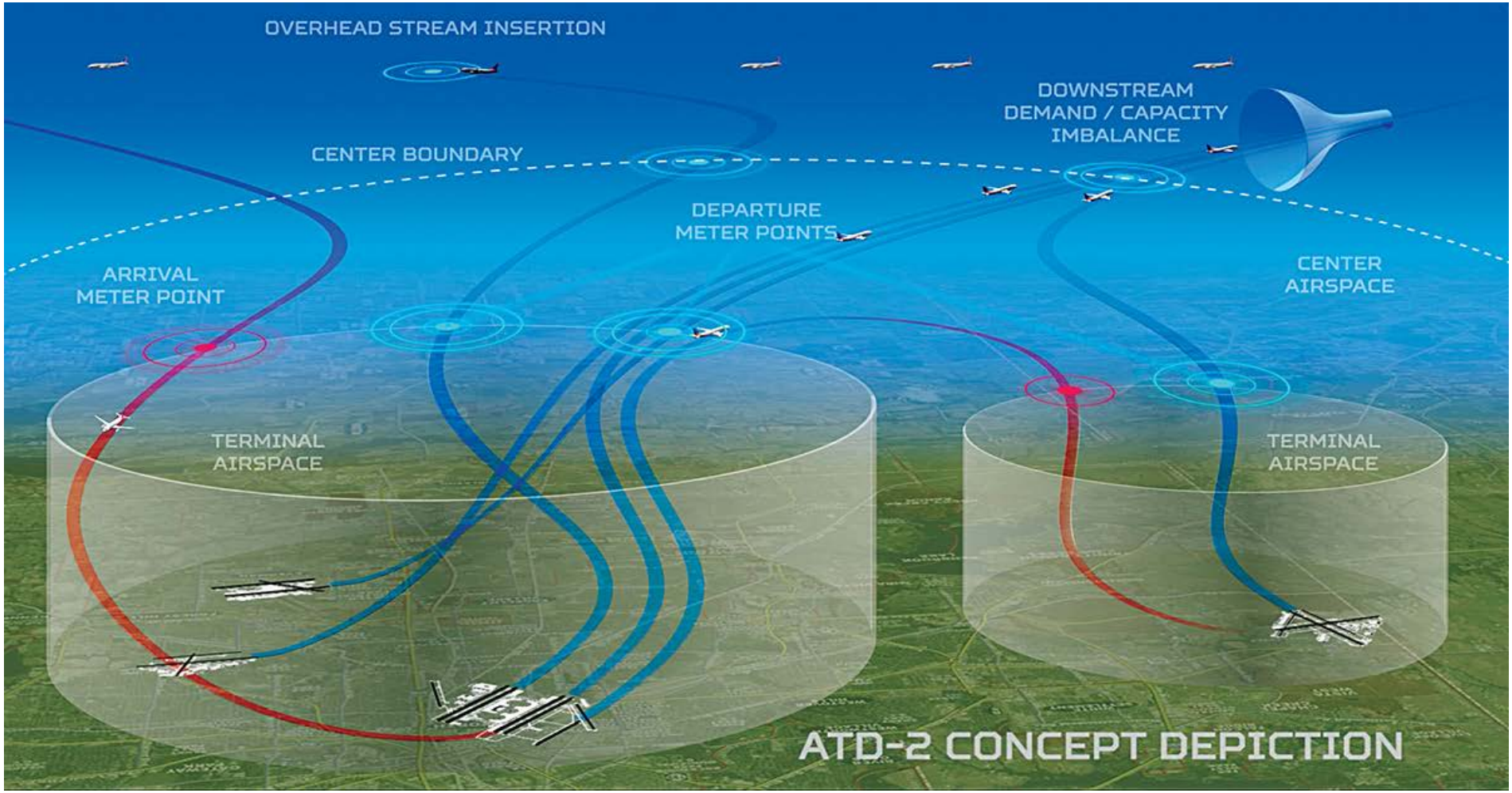
ATM R&D Seminar - Vienna, Austria: June 20, 2019

Background:
Surface Management is a Challenging Task

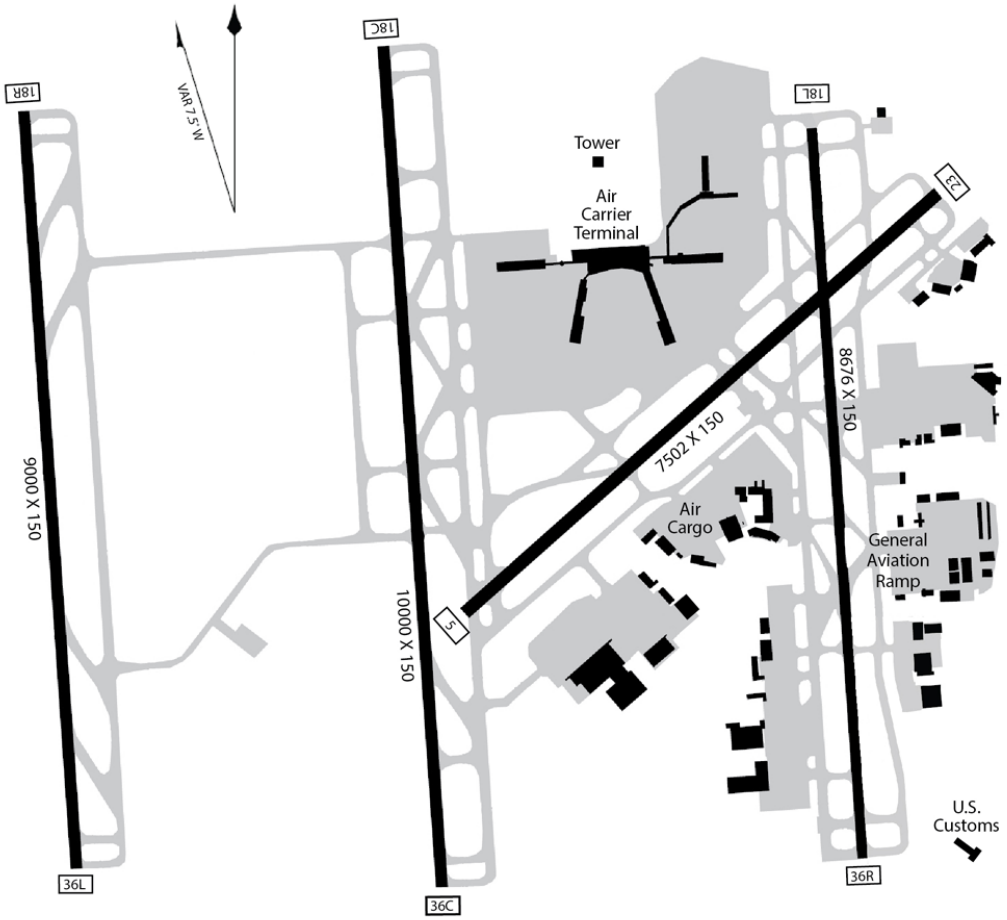
= Departure = Arrival

Background:
Airspace Technology Demonstration 2 (ATD-2)



Integrated Arrival, Departure, and Surface (IADS) traffic management

Phase 1 Field Evaluation at Charlotte Douglas International Airport (CLT) Sep 2017 – Sep 2018



Phase 1 Capabilities Include

- Data exchange and integration
- Departure scheduling for overhead stream insertion
- Tactical surface metering

Phase 1 field evaluation data helped identify scheduler improvements and guided the implementation of refinements enabling strategic Surface Metering Programs (SMPs)

Outline

- Overview of IADS Modeler and Scheduler
- Arrival scheduling
- Departure scheduling for Surface Metering Program (SMP)
- Triggering metering ON
- Compliance with scheduled times
- Summary

IADS Modeler: Trajectory Prediction

- Runway utilization strategy provided by Air Traffic Controllers
- TRACON controller runway intent
- Time Based Flow Management (TBFM) deconflicted Scheduled Time of Arrival (STA)
- Traffic Flow Management System (TFMS) Estimated Time of Arrival (ETA)
- Traffic Management Initiatives (TMIs) and Controlled Takeoff Times (CTOTs)
- Airline provided Earliest Off Block Time (EOBT) estimates
- Tactical airline intent data from ramp controllers

Surface Trajectory Predictive Engine

(runs every 10 seconds)

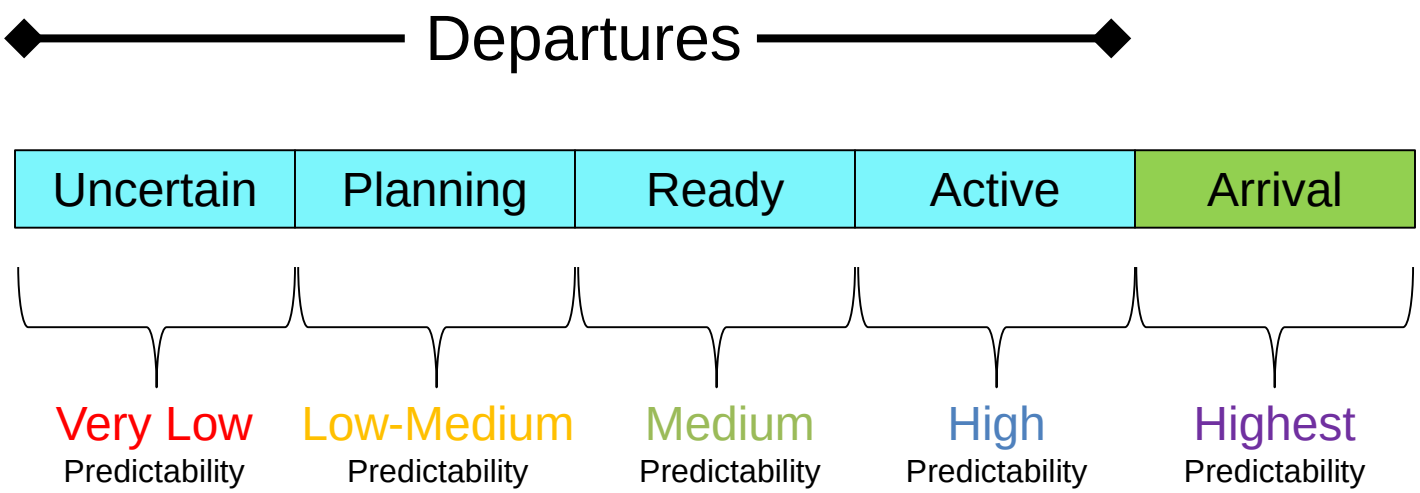
Departure Trajectory Logic:

- **Earliest Off Block Time (EOBT)**
- **Unimpeded Off Block Time (UOBT)**
- **Unimpeded Movement Area entry Time (UMAT)**
- **Unimpeded Take Off Time (UTOT)**
- **Pushback duration model**
- **Ramp and AMA taxi time**
- **Trajectory Hovering Logic**

Arrival Trajectory Logic:

- **Predicted landing time**
- **Ramp and AMA taxi time**
- **IN time estimate for gate conflicts**
- **Gate conflict prediction**

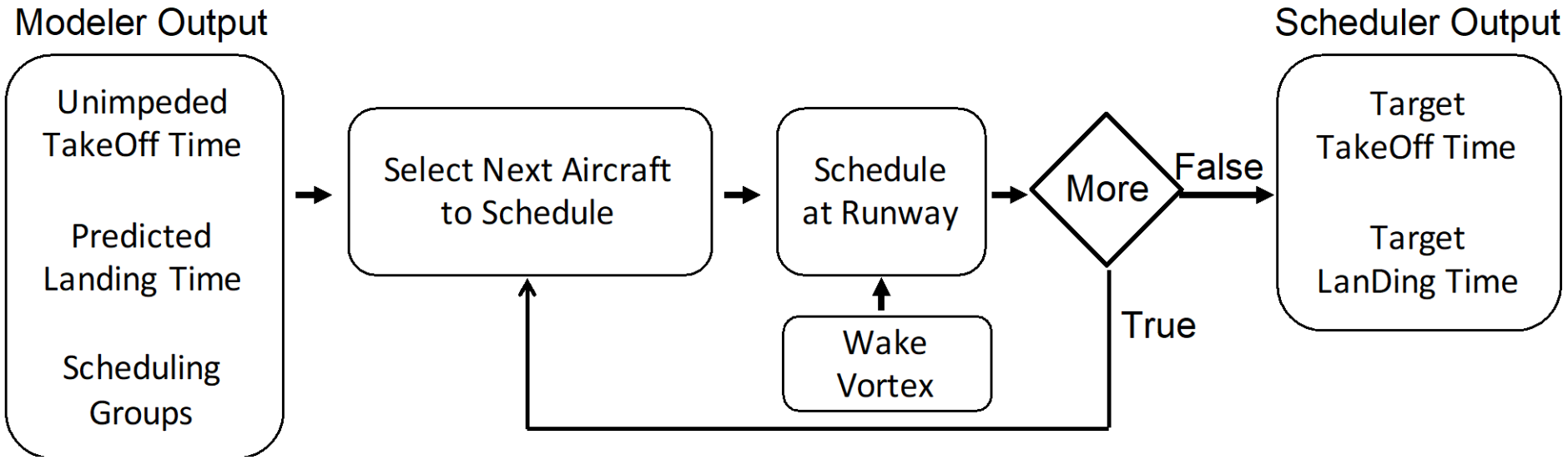
IADS Modeler: Scheduling Groups



- Flights assigned to scheduling groups using flight state and Earliest Off Block Time (EOBT) estimates provided by the airlines
- Scheduling groups used in logic to select next aircraft to schedule, e.g., all arrivals placed on timeline before departures

IADS Scheduler Logic

Step 1: Target TakeOff Time (TTOT)



Step 2: Target Off Block Time (TOBT)

$$TOBT = \max[\, UOBT\ ,\ TTOT - UTT - TargetExcessQueueTime \,]$$

UOBT = Unimpeded Off Block Time (from the airlines)
UTT = Unimpeded Transit Time (from the model)

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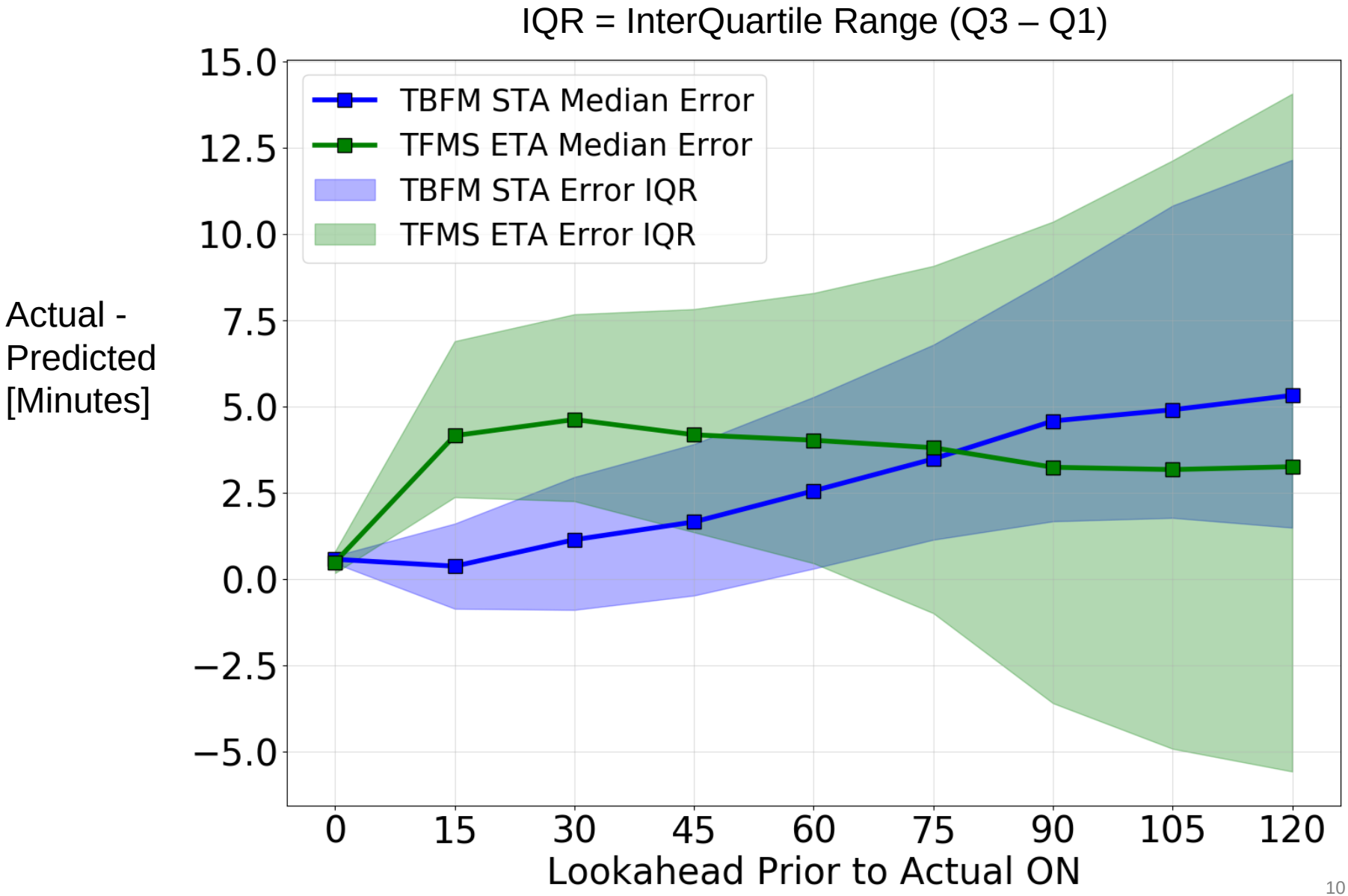
Predicted Landing Time Accuracy



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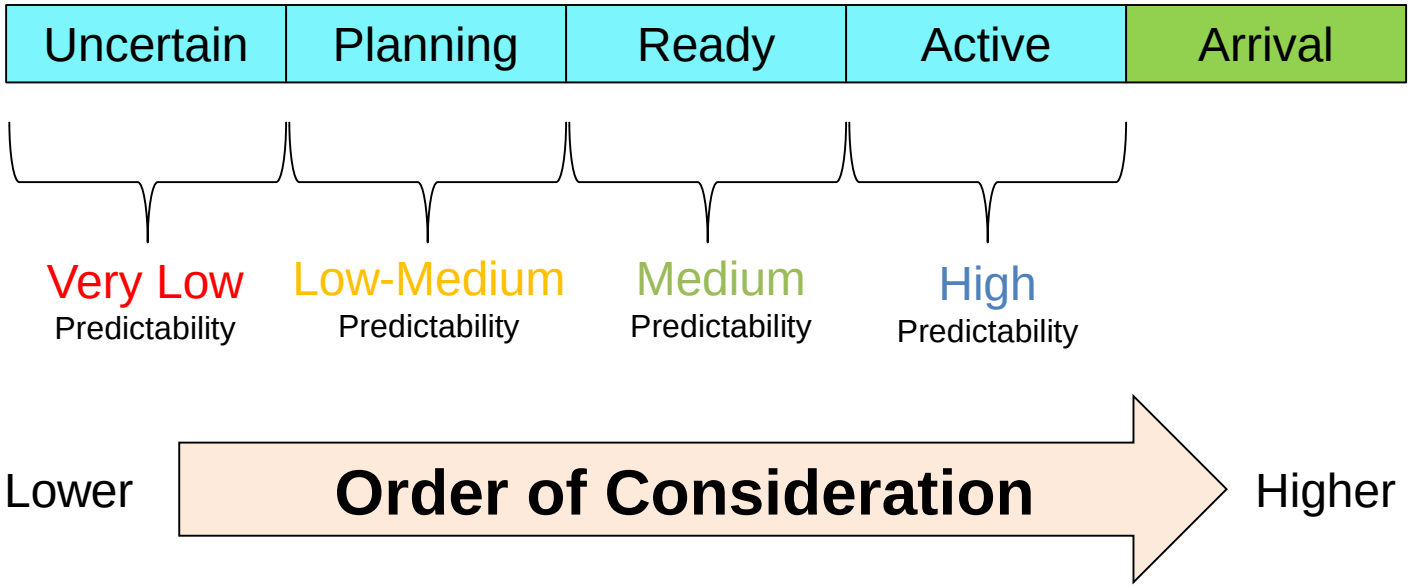
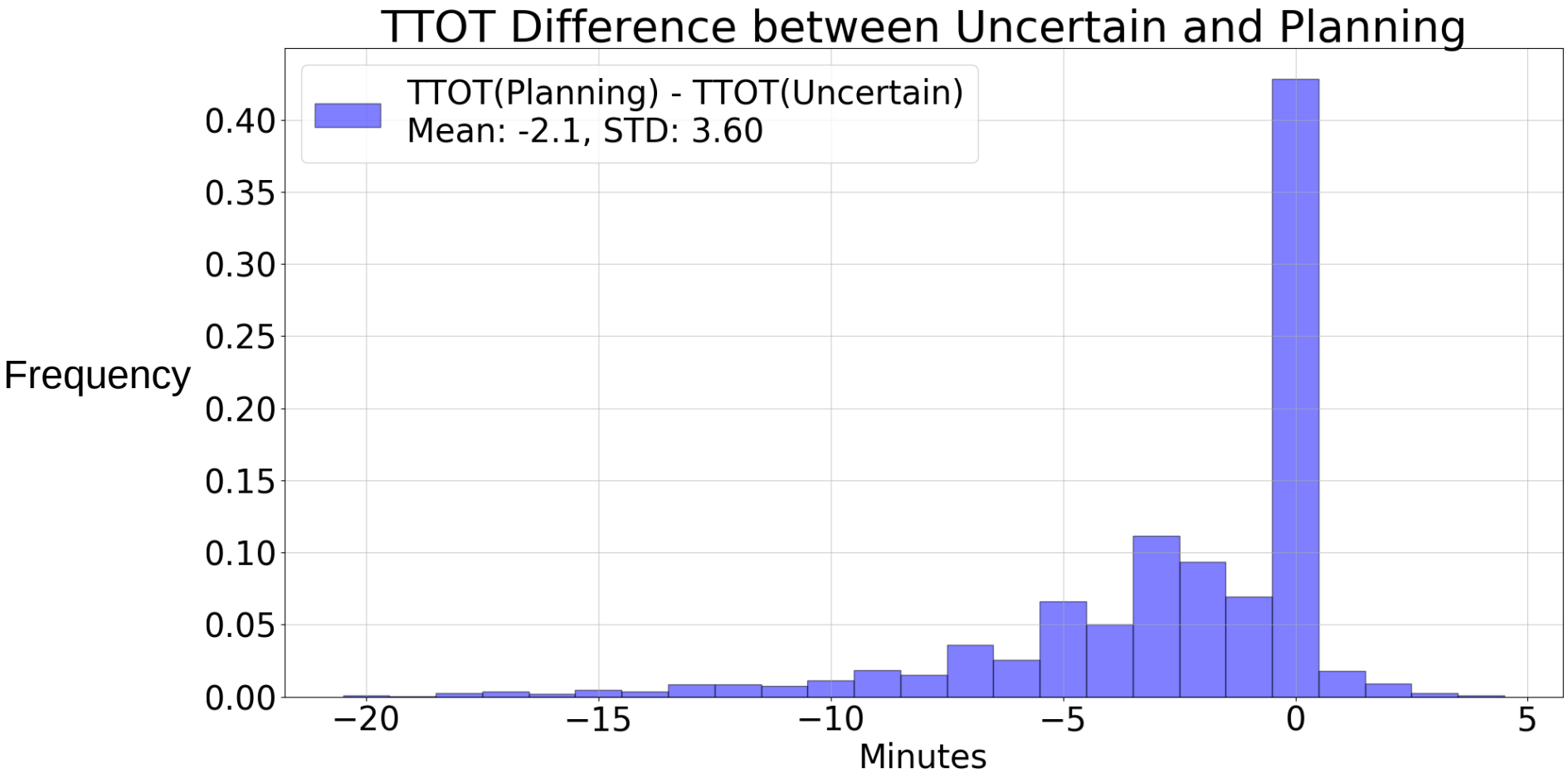
Original Scheduler Design to Select Next Aircraft to Schedule



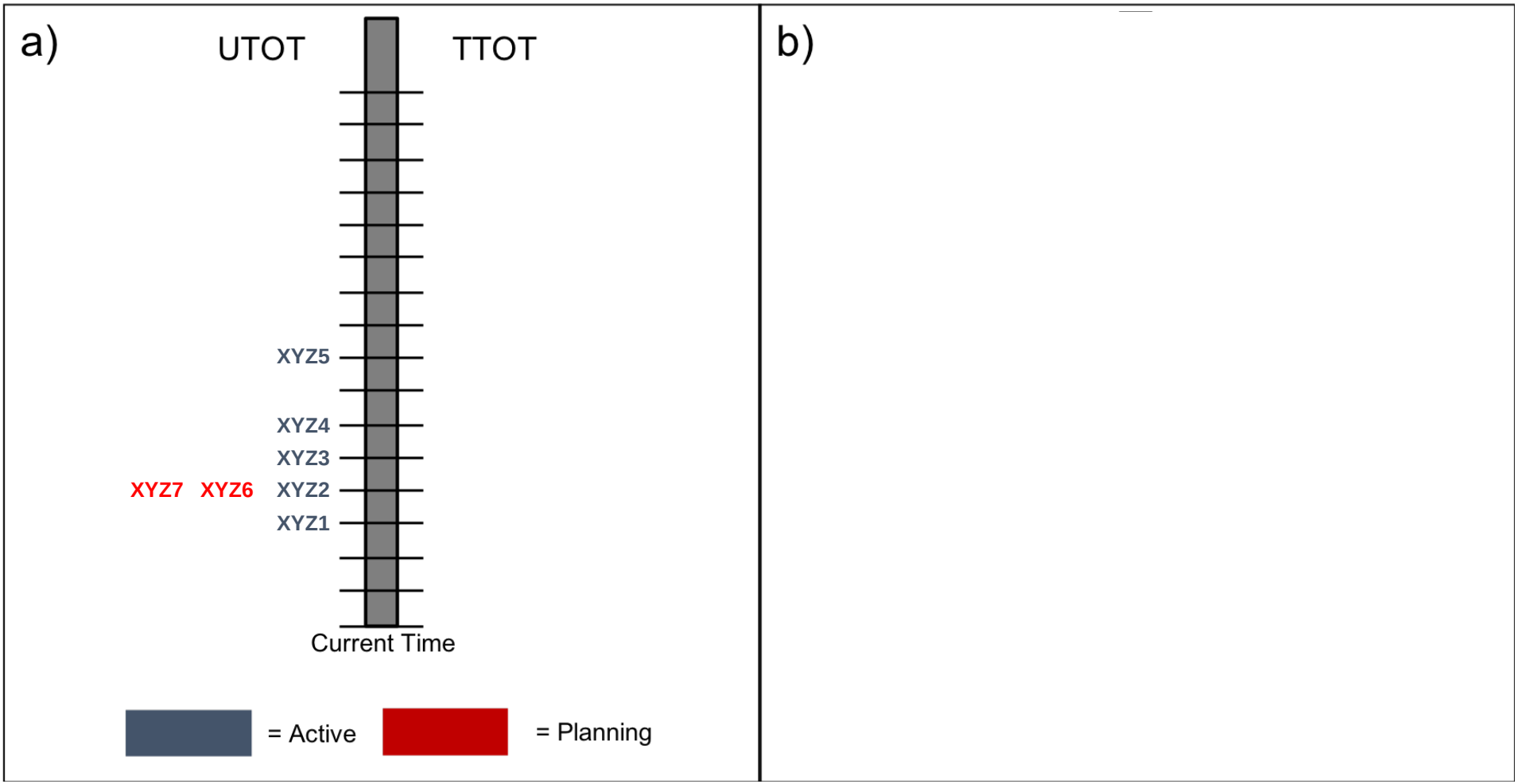
- Departures placed on timeline after arrivals according to the Order of Consideration
- Original design inserted aircraft into the schedule in a hierarchical fashion where each group was scheduled before moving to next group
- This hierarchical structure creates instability when aircraft transition between groups

Target Take Off Time (TTOT) when Transitioning from Uncertain to Planning



Target TakeOff Time (TTOT) Instability from Hierarchical Order of Consideration

UTOT = Unimpeded TakeOff Time (from modeler)
TTOT = Target TakeOff Time (from scheduler)



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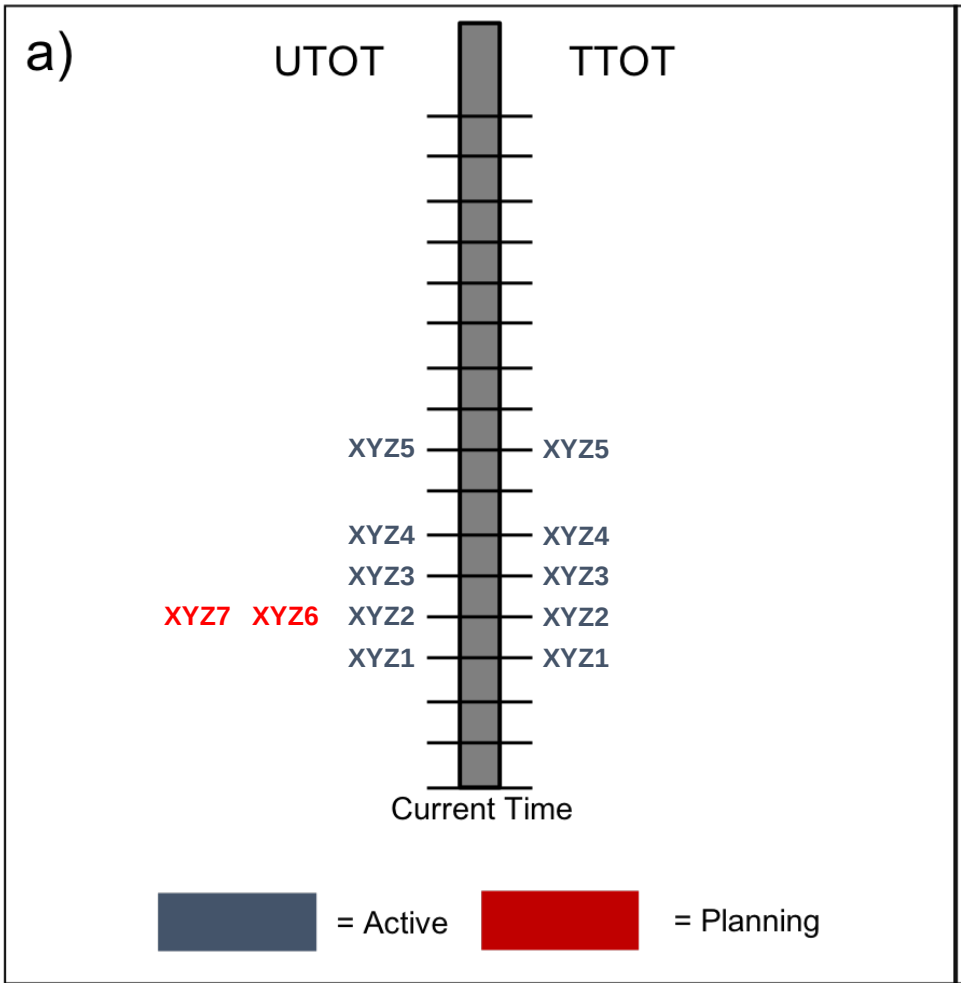

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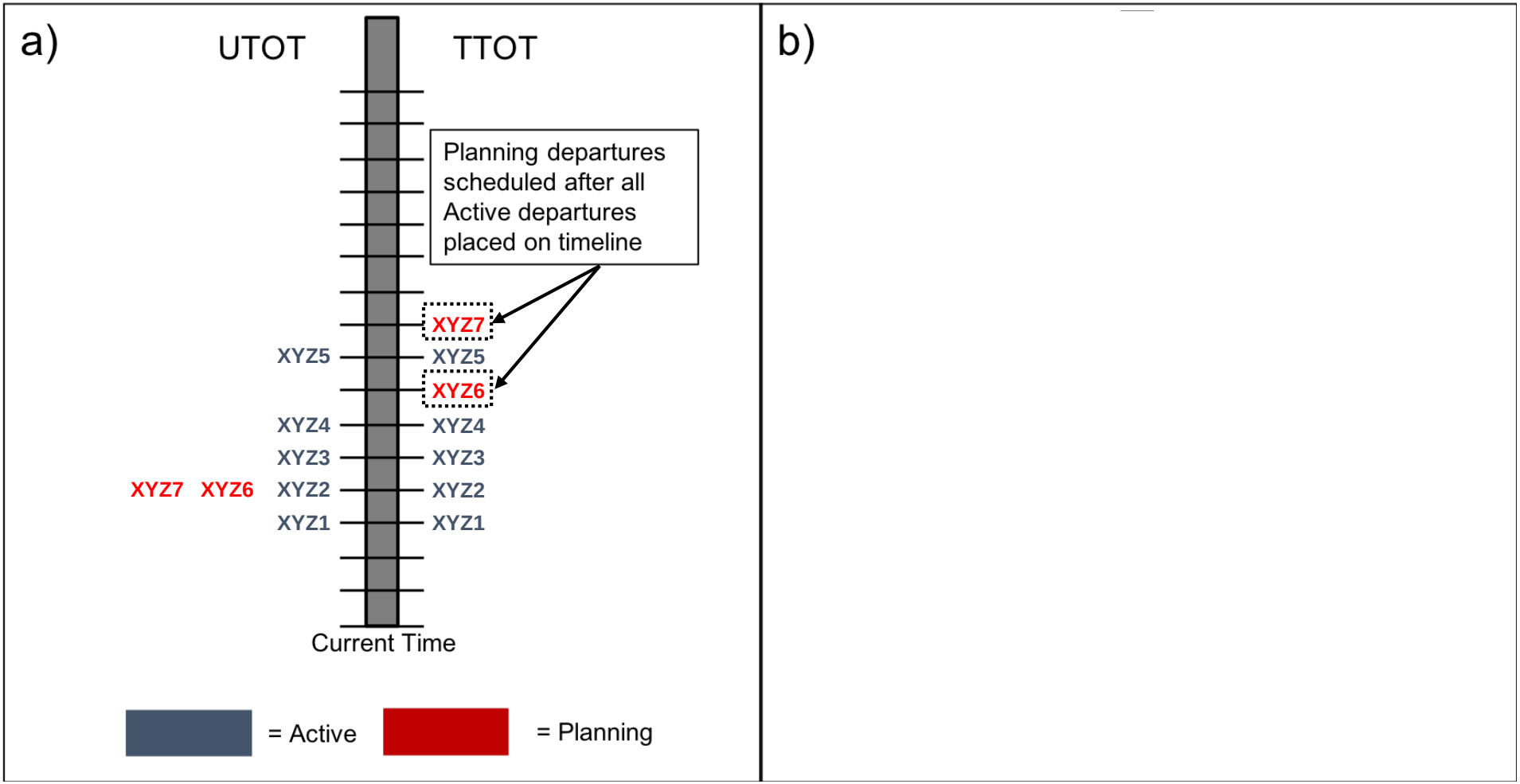

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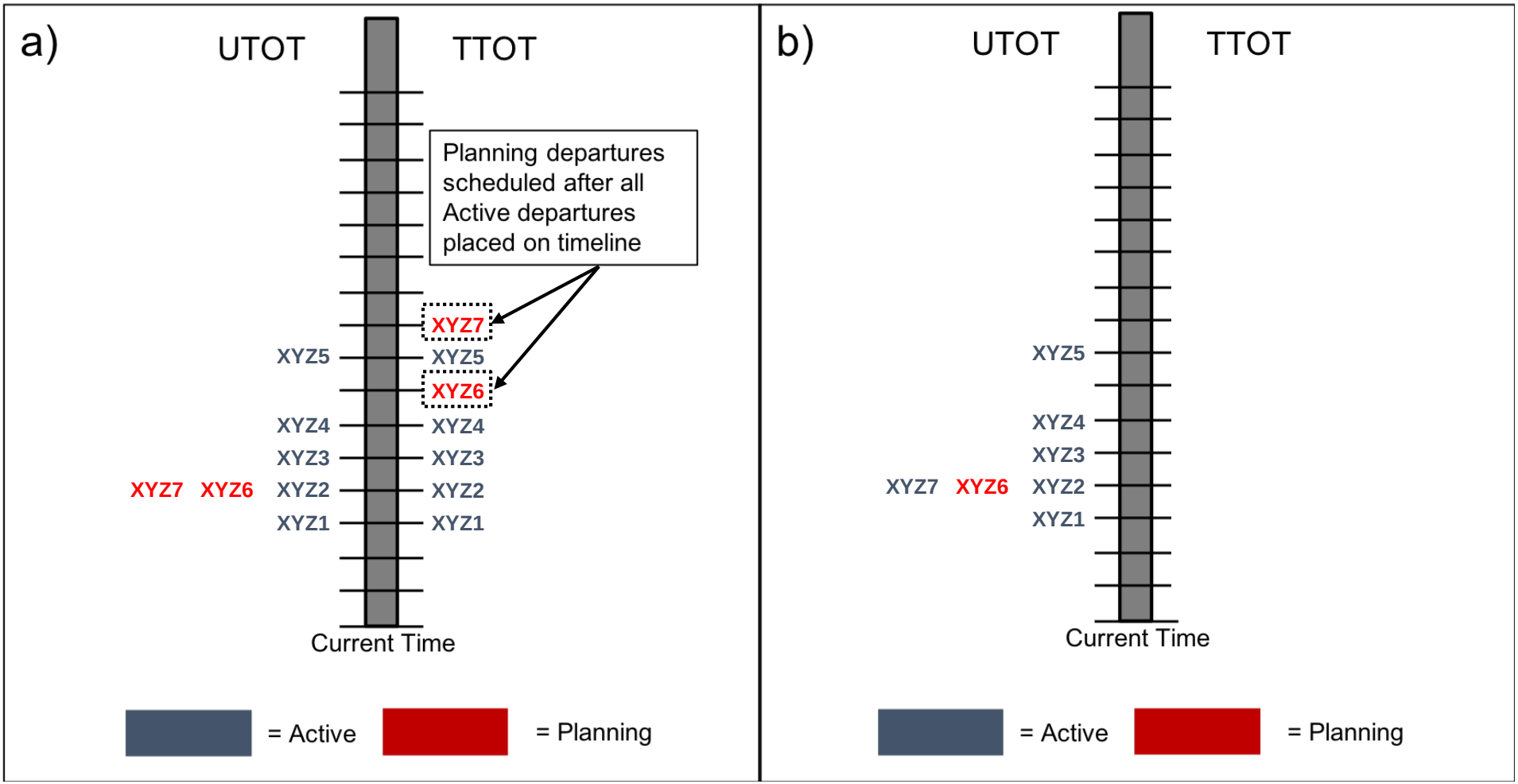

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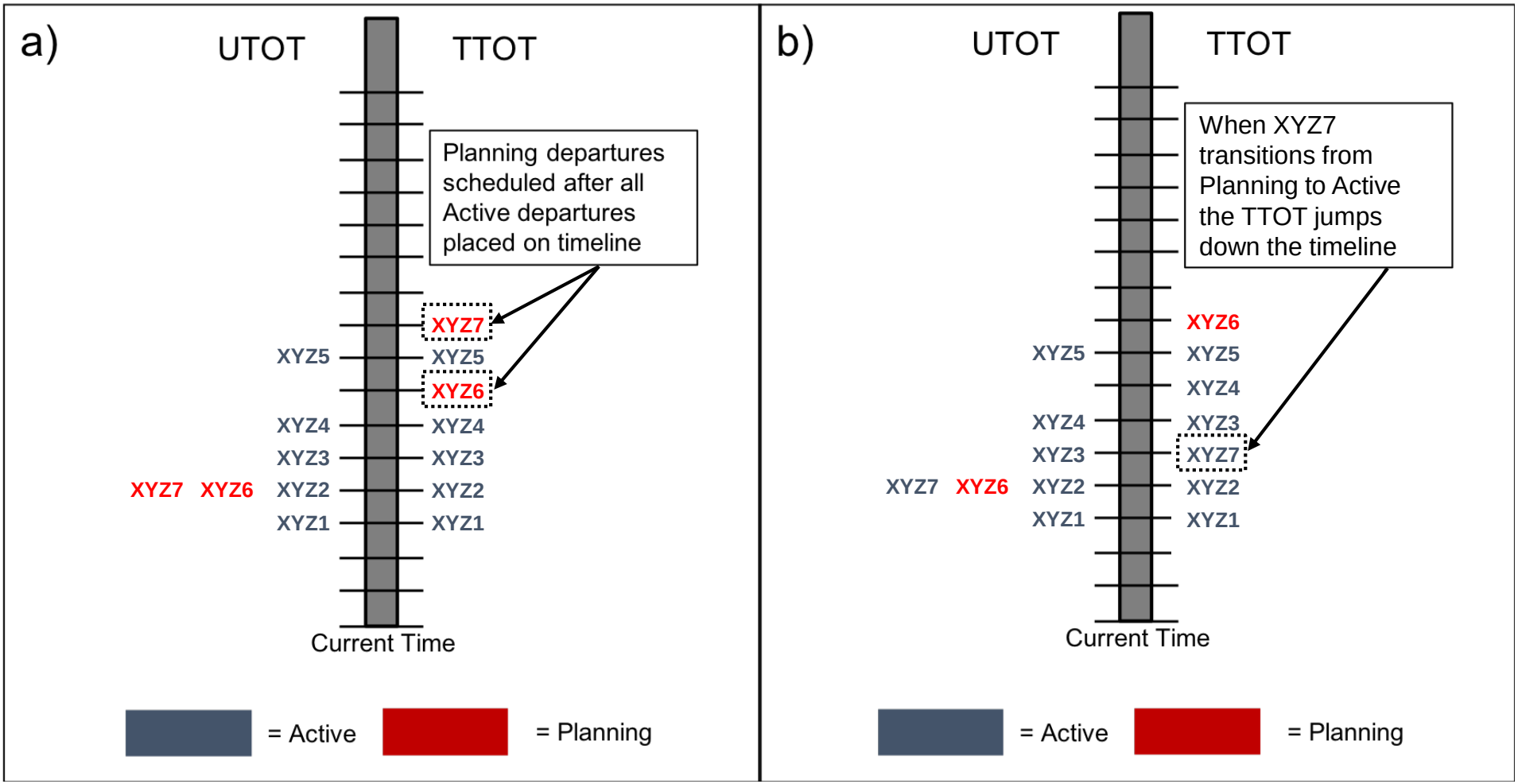
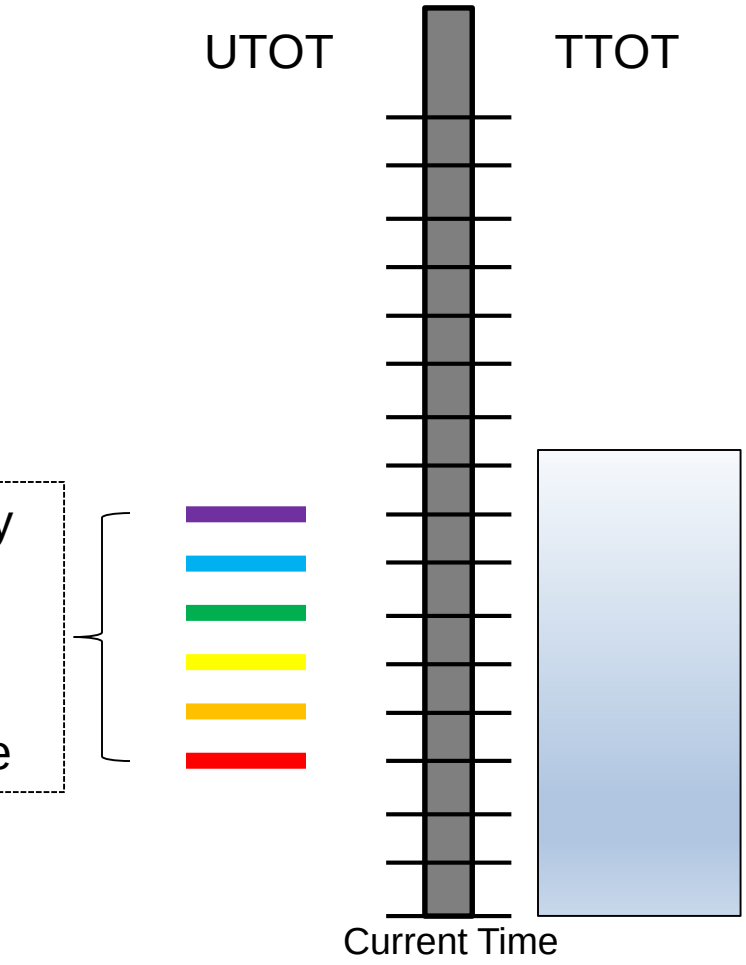


First Scheduled First Served (FSFS) in Planning Group for Surface Metering Program

UOBT = Unimpeded Off Block Time (from modeler)
SOBT = Scheduled Off Block Time (from airline)



Sequence defined by First Come First Served (FCFS) principle:
UOBT + Transit Time

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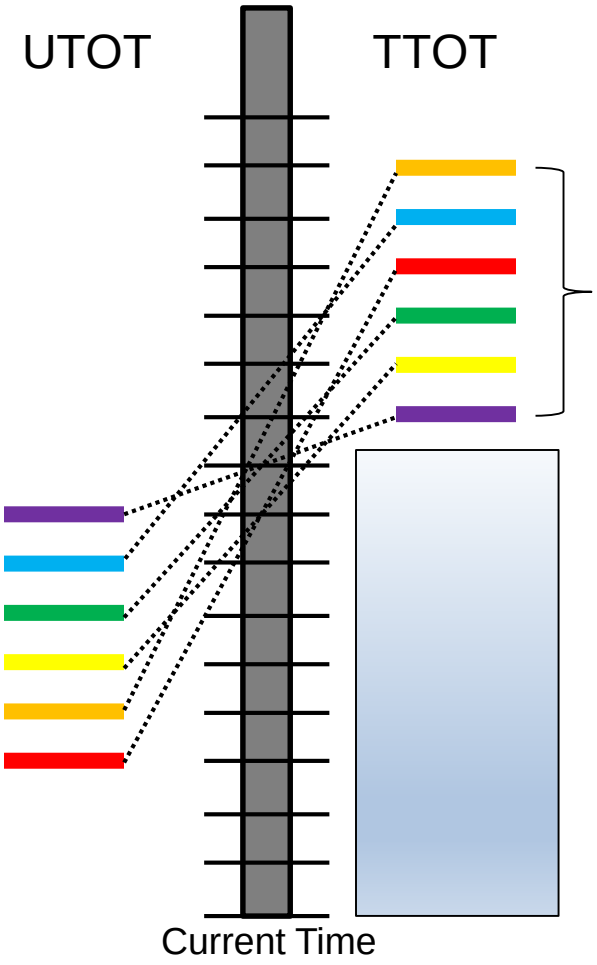

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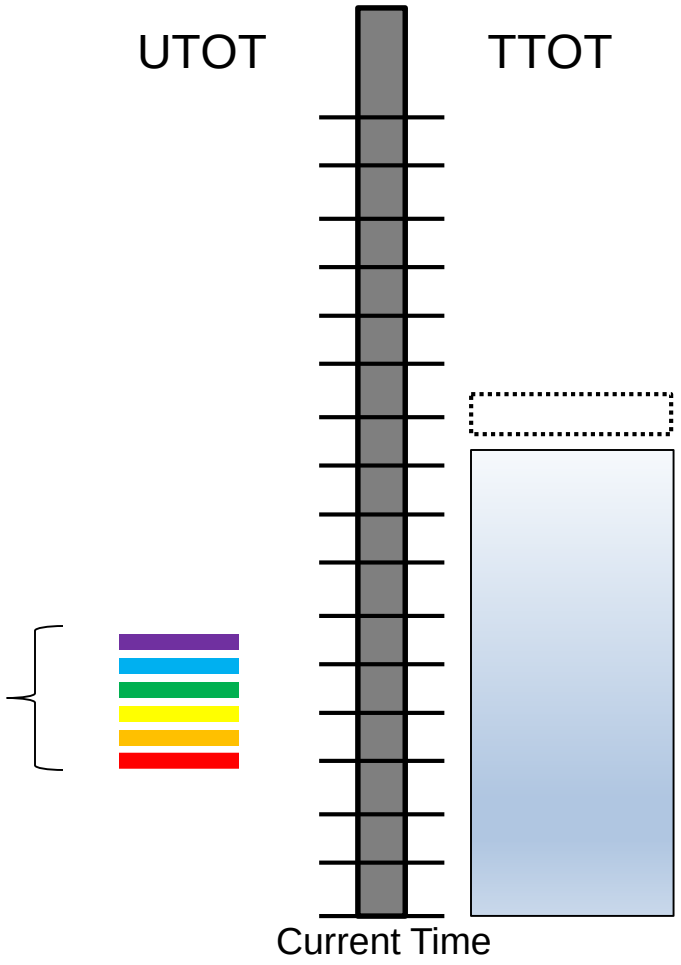

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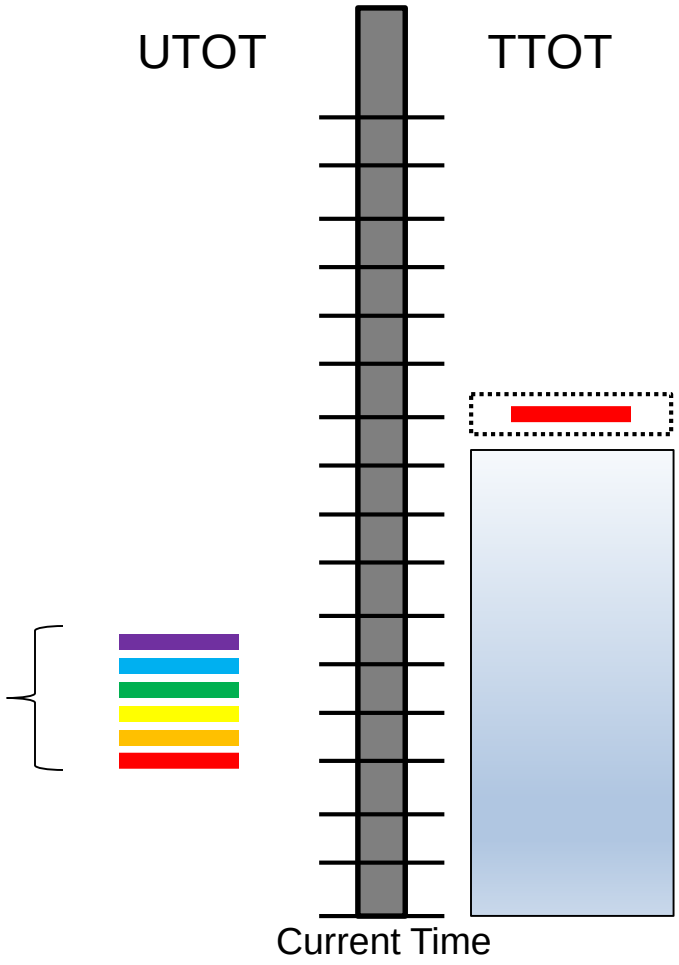

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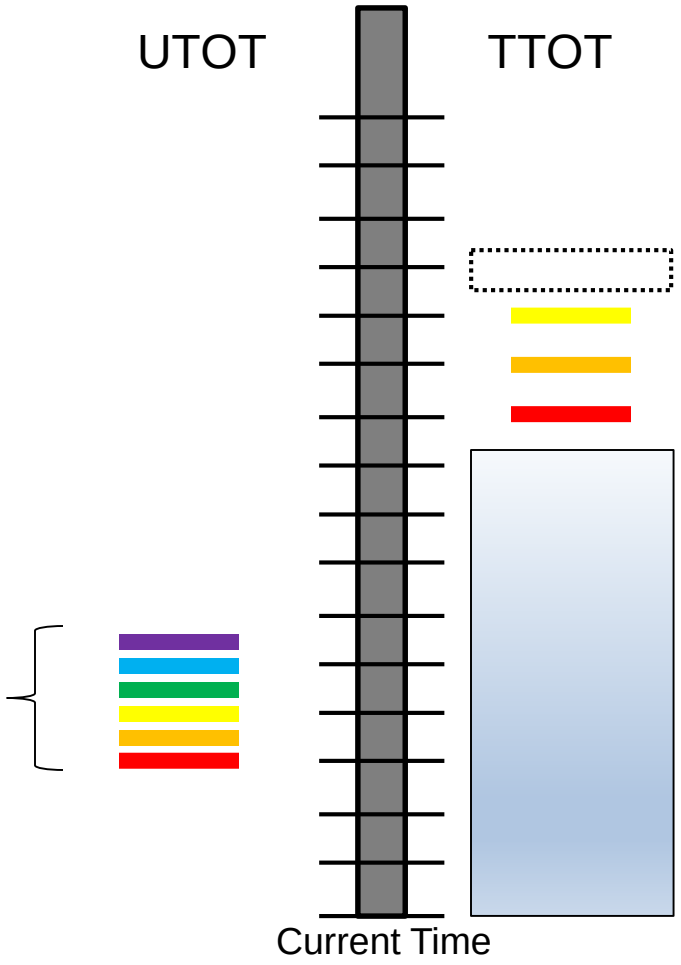

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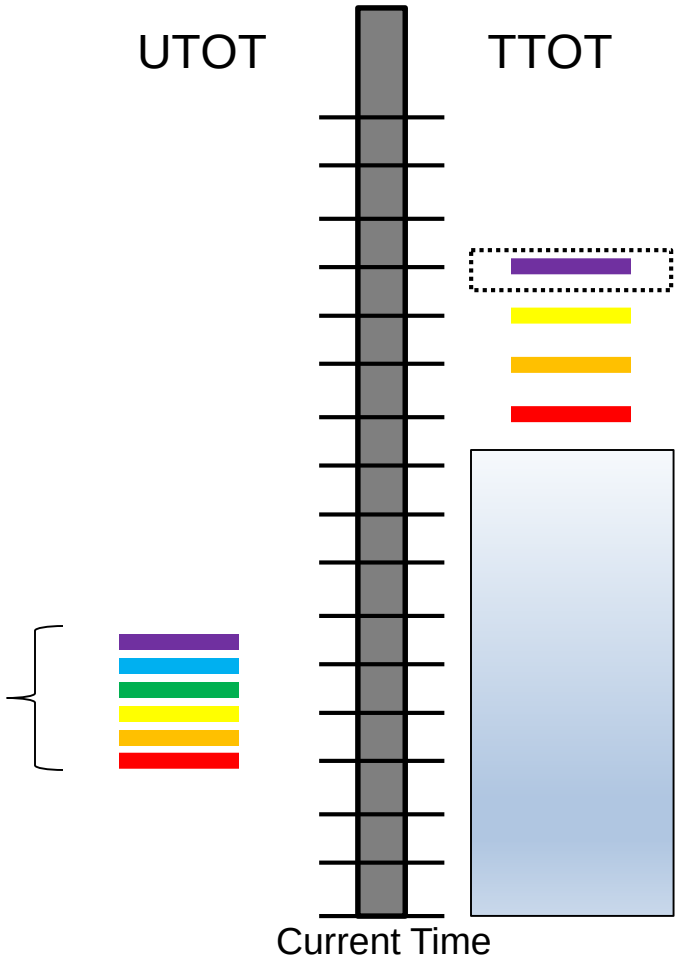

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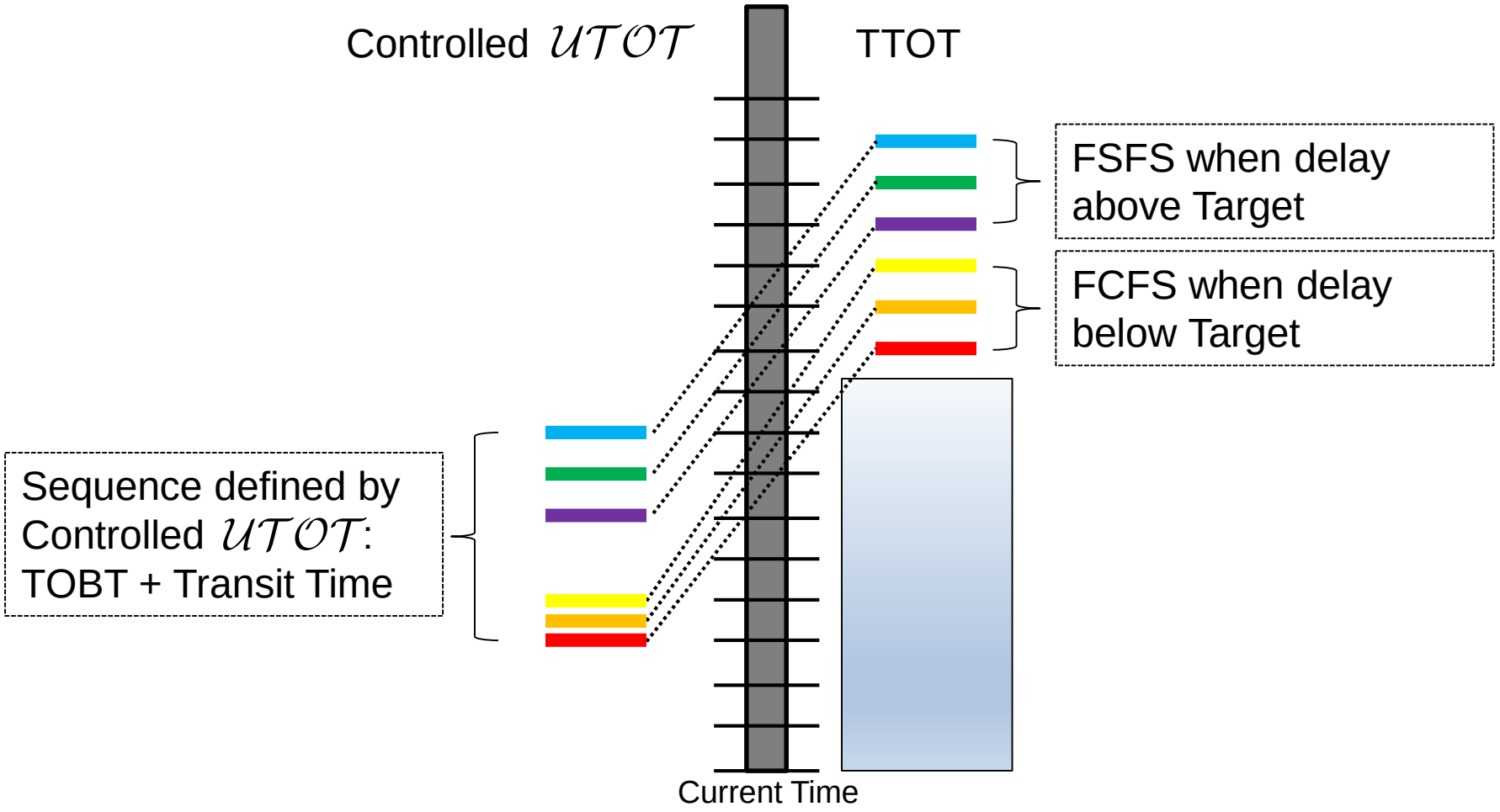
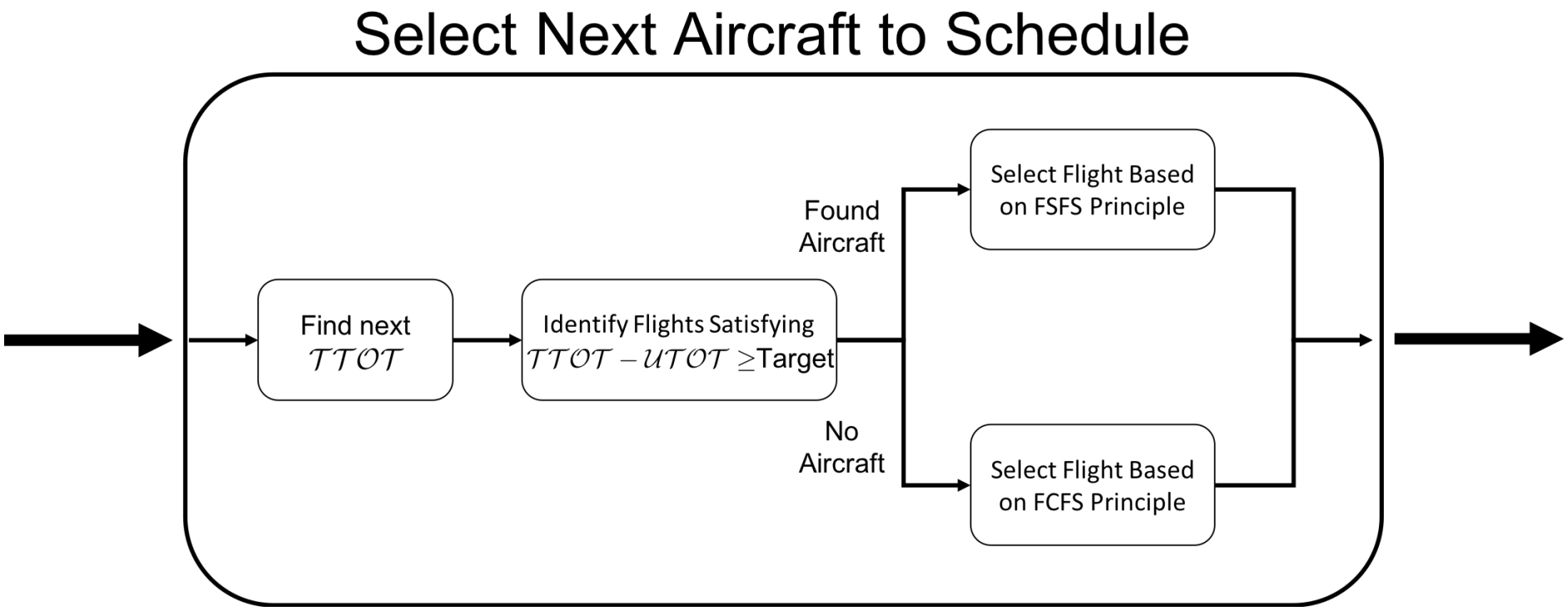
First Scheduled First Served (FSFS) in Planning Group for Surface Metering Program

TOBT = Target Off Block Time (from scheduler)



Identifying When to Use First Scheduled First Served (FSFS) vs. First Come First Served (FCFS)



Delay above the Target excess queue time gives us the ability to gate hold and *influence* the sequence of aircraft that we deliver to the runway

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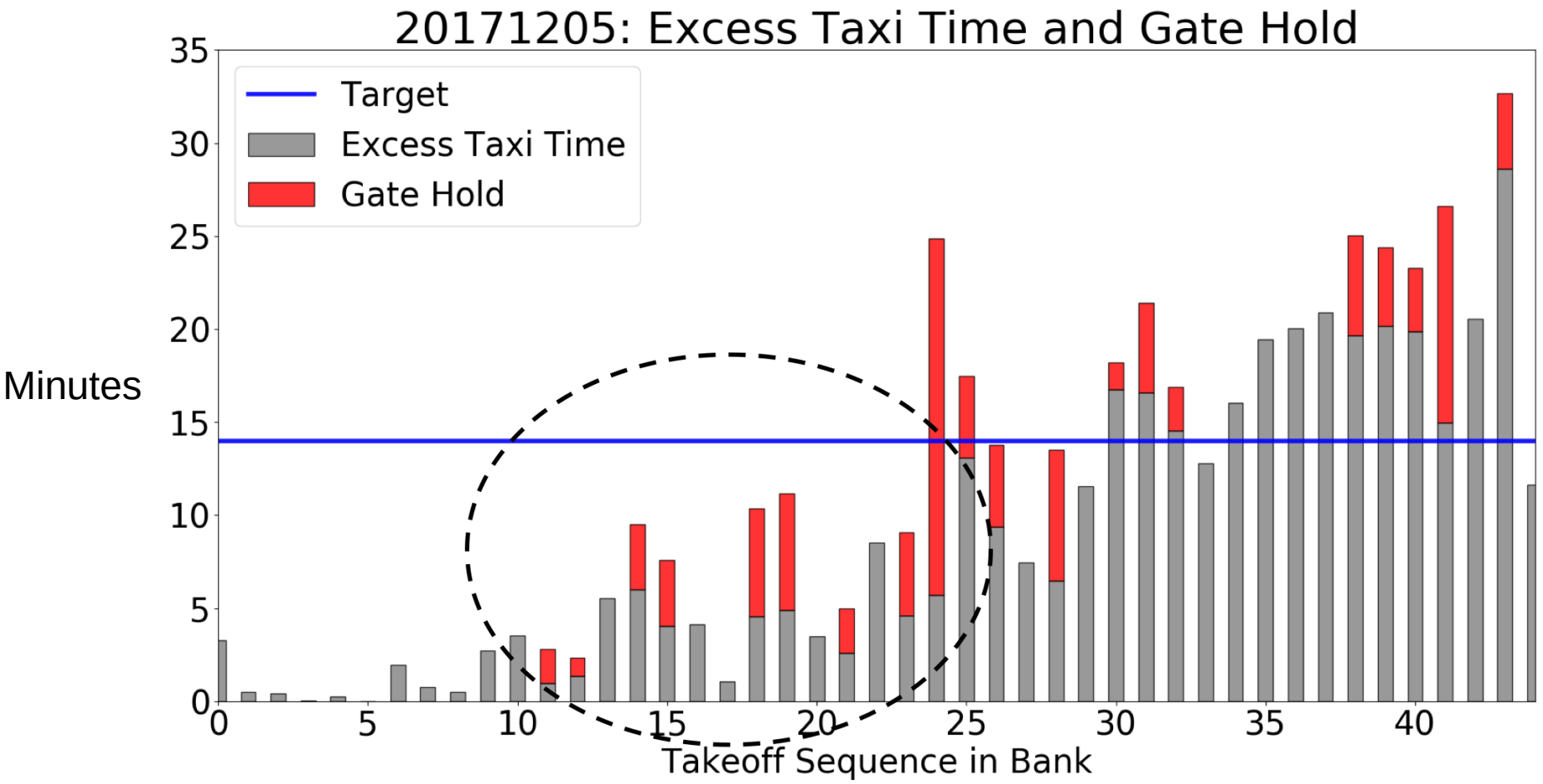
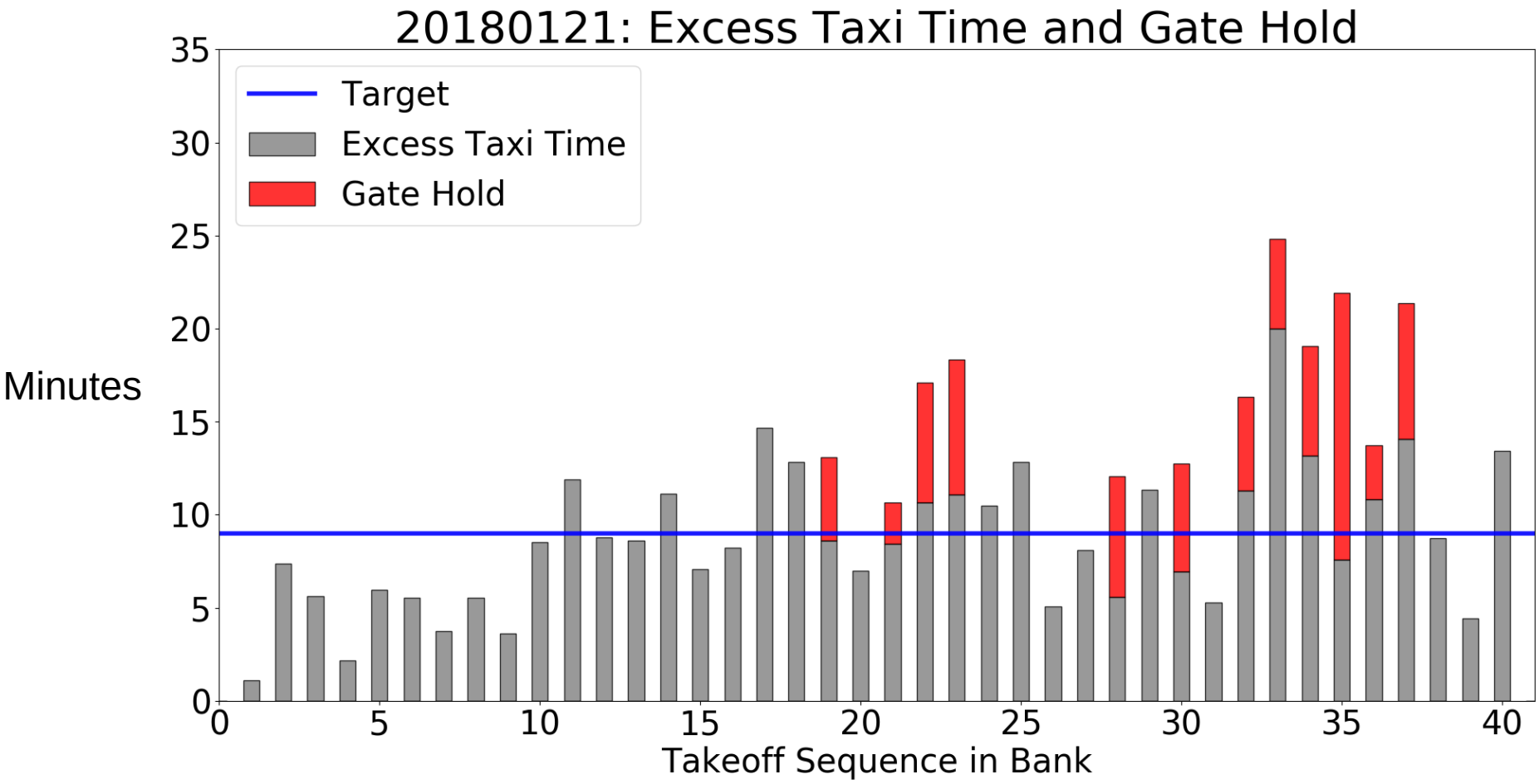
Original Design: Trigger Metering ON Using Delay Predictions Based on EOBT



Metering triggered ON early and aircraft were gate held when the delay was well below the Target excess queue time

Revised Design: Trigger Metering ON Using Active Flights Delay and Delay Predictions



Metering triggered ON after delay naturally built up to the Target and additional delay was efficiently transferred from the taxiways to the gate

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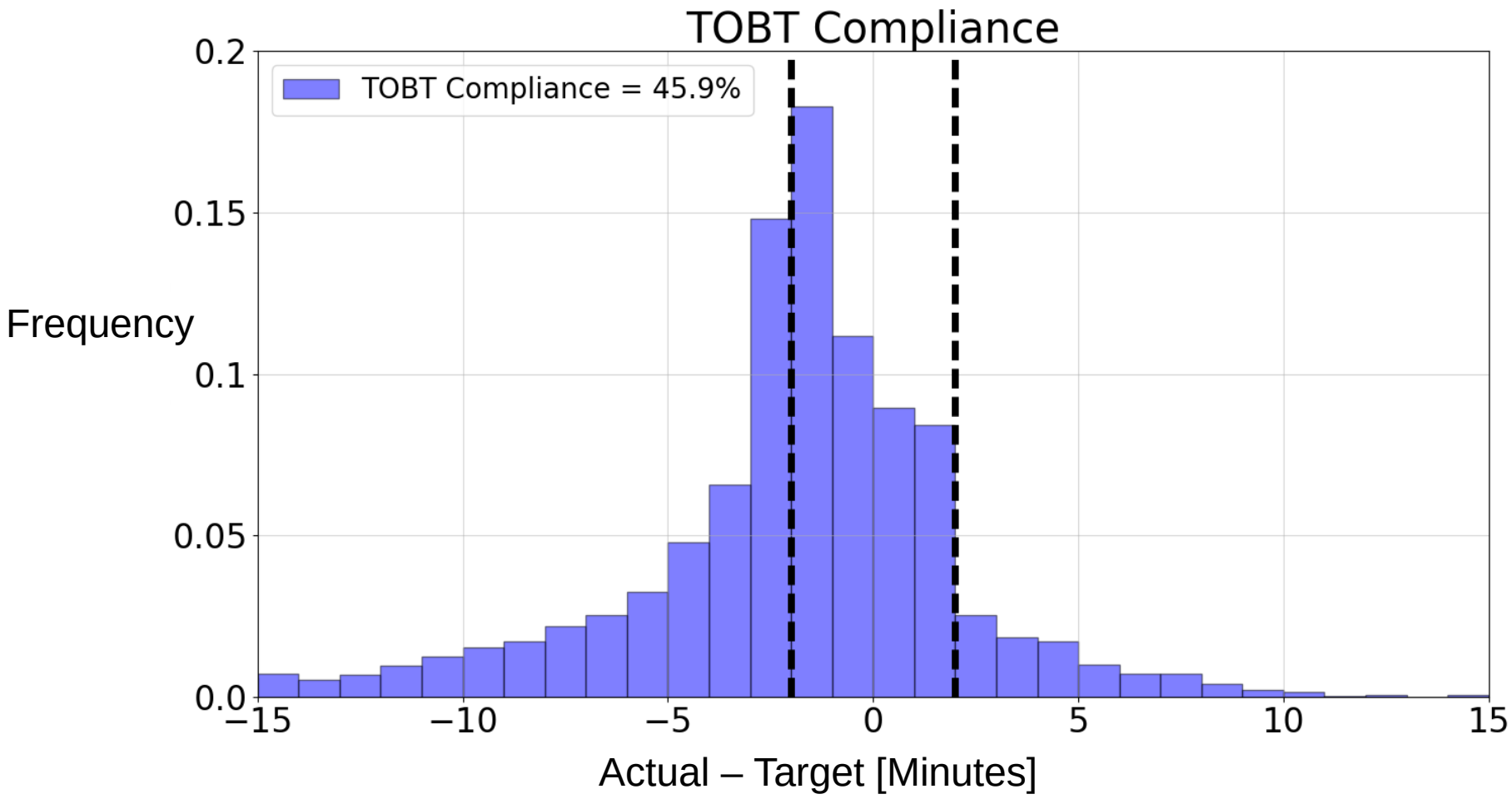
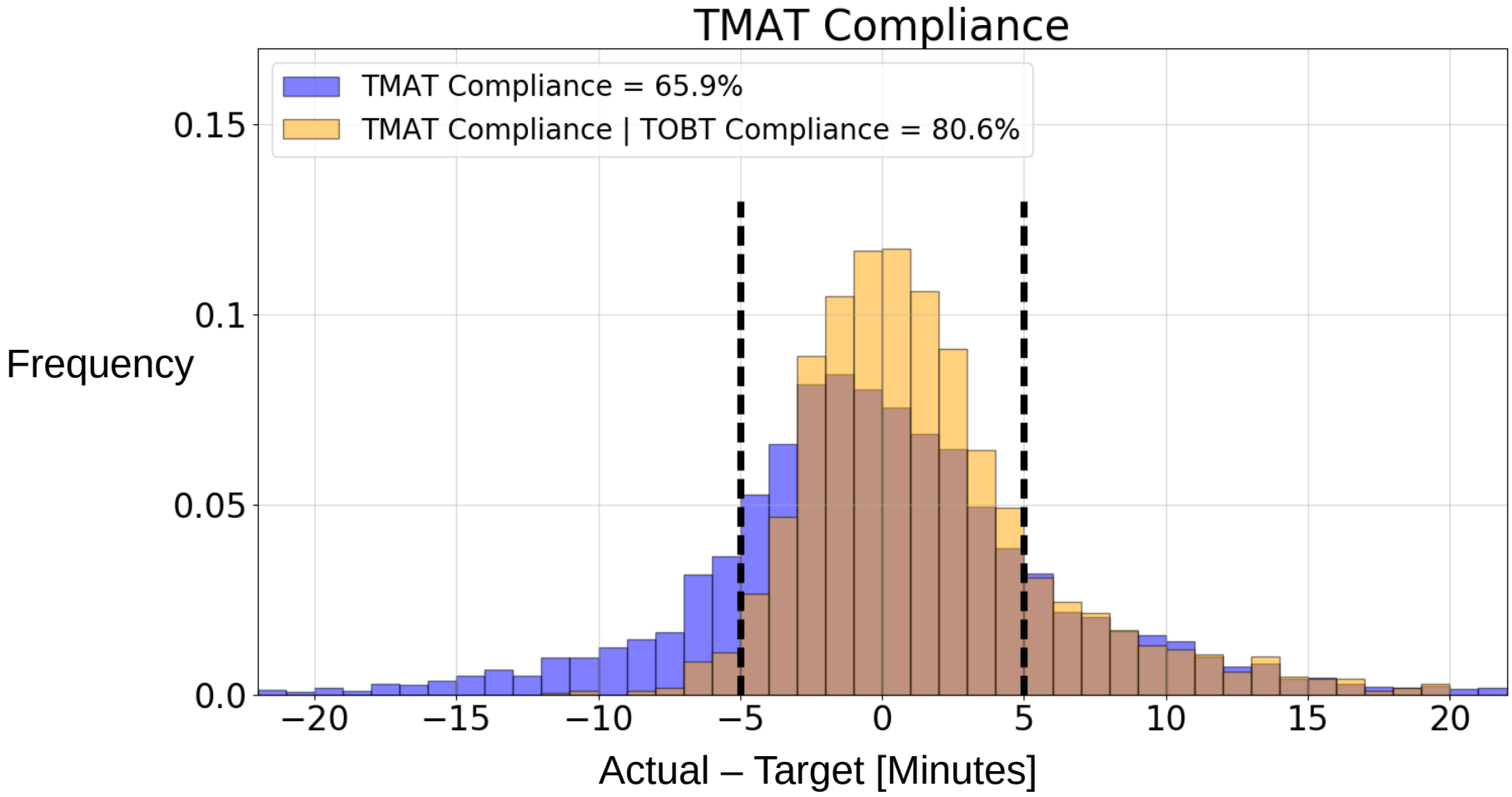
Target Off Block Time (TOBT) Compliance +/- 2 Minutes

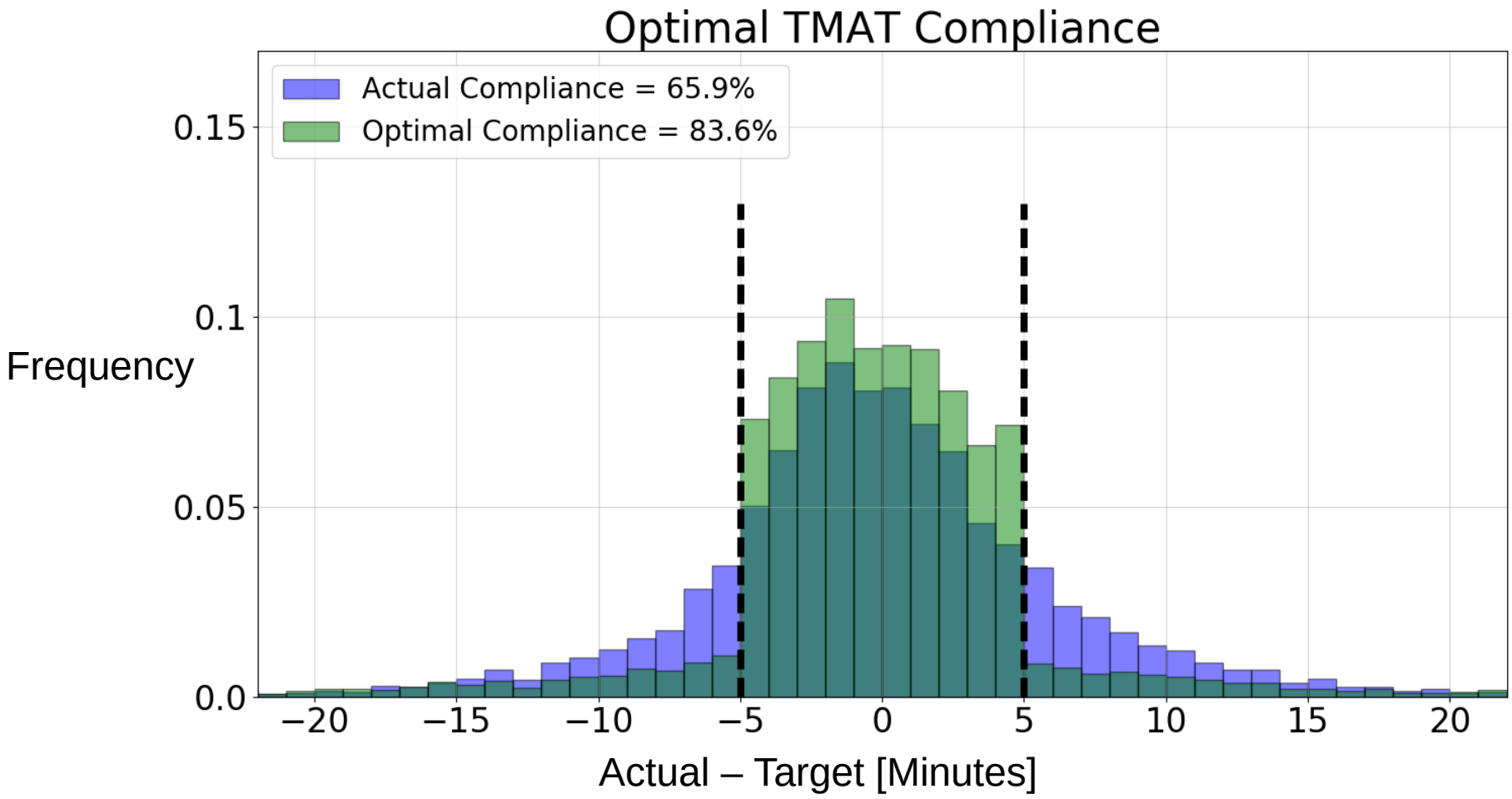


Target Movement Area entry Time (TMAT) Compliance +/- 5 Minutes



Compliance with the TMAT increased when aircraft were initially compliant with the TOBT

Optimal Target Movement Area entry Time (TMAT) Compliance +/- 5 Minutes



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Summary

- Arrival scheduling

  Predicted Landing Times for arrivals use TBFM STA when available else use TFMS ETA

- Departure scheduling for Surface Metering Program (SMP)

  Delay beyond the Target excess queue time gives us the ability to influence the sequence of aircraft

- Triggering metering ON

  Triggering metering ON performed best when accounting for active flights delay in addition to delay predictions

- Compliance to scheduled times

  TMAT compliance increased when aircraft were first compliant with the TOBT

Next Steps

- Evaluate the performance of strategic Surface Metering Programs (SMPs)
- Improve and evaluate performance of departure scheduling for overhead stream insertion including prescheduling with Earliest Off Block Time (EOBT)
- Incorporate constraints from the terminal boundary in a metroplex environment
- Tactical scheduling with Trajectory Option Sets (TOS)

Questions?

POC Jeremy Coupe: william.j.coupe@nasa.gov